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# GUIDE TO USE OF WOOD AS AN ALTERNATE MATERIAL IN AGRICULTURAL IMPLEMENTS

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# GUIDE TO USE OF WOOD AS AN ALTERNATE MATERIAL IN AGRICULTURAL IMPLEMENTS

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The past few months have witnessed the development of shortages in several important raw materials used in farm equipment prior to the war. Due to the necessity not only of maintaining but even considerably increasing the production of farm crops the shortage of such raw materials as iron, copper, rubber, etc., cannot be permitted to stand in the way of an output of essential farm equipment.

The notable developments in farm equipment have come in the present generation largely because of the substitution of mechanical for animal power. Steel has replaced wood in many places where it is the better material for the use. At the same time steel in various forms has been used in some items where wood can serve without much change either in service or design. Right now it is important that all items of equipment be thoroughly analyzed with the objective of using wood wherever it is adaptable in an effort to conserve metals that are essential in the war program. It is not necessary to go beyond the uses where wood can be used to advantage to arrive at totals that represent substantial savings of metal and rubber.

On the basis of information, both from manufacturing plants and Laboratory research, subject matter is presented in this report that will be helpful to manufacturers and to others looking for opportunities to replace critical materials.

## Implement Parts of Similar Use Requirements

Many implements in the agricultural machinery field have parts or assemblies for which the requirements are similar. It is possible, therefore, to group items on a use requirement basis even though the implements embodying these parts may be quite dissimilar. For instance, Guide Handles may be set up to apply to all walking implements, such as plows, planters, cultivators, hillers, and diggers. The function of the guide handles for these various implements is the same, and a material that is suitable for one is suitable for another. Naturally plow handles must be capable of withstanding greater loads than garden cultivators. But, essentially, if wood will serve for one it will serve for the other.

Table 1 is a listing of parts of similar service requirements where wood has been used with satisfaction in the past or where it is reasonable to conclude that it can be used now as a means of reducing the drain on critical metals. At this time mere preference for a given material cannot be a deciding factor; it is a matter of necessity to use the most serviceable and economical material that is available in quantity. Wood, right now, is a material that meets these conditions in numerous cases.

Table 1.--Grouping of farm implement items on basis of similar use requirements

| Typical use groups | Suggested form of wood stock | | |
|---|---|---|---|
| | Lumber | Dimension stock | Plywood or fibre board |
| Beams | | x | |
| plows, cultivators | | | |
| Conveyor chutes | x | | |
| elevators, shellers, threshers | | | |
| Conveyor slats | | x | |
| binders, elevators, pickers, loaders | | | |
| Floors | x | | |
| wagons, spreaders | | | |
| Framework | x | x | |
| peanut pickers, poultry batteries, feeders, grinders | | | |
| Handles, guide | | x | |
| plows, cultivators, planters | | | |
| Hitch parts | | x | |
| wagons and other horse-drawn implements | | | |
| Hoppers | x | | x |
| drills, fertilizers, lime sowers, planters, feeders | | | |
| Levers | | x | |
| harrows, mowers, rakes, plows | | | |
| Panels | x | | x |
| hammer mills, incubators, threshers, shellers | | | |
| Poles or tongues | | x | |
| wheeled implements, wagons | | | |
| Reels | x | x | |
| binders, combines | | | |
| Running gears | | x | |
| wagons, manure spreaders, rakes, drills | | | |
| Skids | x | x | |
| engines, portable feeders and brooders | | | |
| Tanks | x | x | |
| watering, storage, spraying, cooling | | | |

Table 1 also indicates what seems to be the logical form of wood product to use for the various parts. In solid form wood can be bought as lumber in whatever quality classes or grades the manufacturer may elect to use. As dimension or ready-cut stock it is available from both sawmills and plants specializing in fabricated parts. Also millwork and furniture plants may be looked to as potential suppliers of machined and ready-to-use parts.

In sheet form plywoods and dense fibre and mineral boards will give service in many cases comparable to that rendered by sheet metal or solid lumber. Where coverage is the chief purpose to be served plywood of two general types based on adhesive used in manufacture is in the picture: (1) Ordinary or interior type for equipment kept inside or operated outside only in dry weather, and (2) weather-resistant or exterior type for equipment that may be subject to longer periods of exposure to the weather or to other damp conditions. The compressed fibre boards also come strongly into the picture for coverage purposes. Especially where there is some fire hazard, as in incubators, the mineral boards, such as asbestos-cement or gypsum compositions, have special virtue.

Designs may need altering to make changes from sheet metal to these materials; curved surfaces may have to give way to flat ones, because neither thick plywoods nor wall boards as normally manufactured will take extreme curvature.

Wire used extensively in some poultry equipment may be replaced by wooden dowels or wooden lattice work.

## Choice of Woods for Farm Implements and Equipment

Table 2 deals with the selection of species for the component parts of farm implements and equipment. The list is not complete from the standpoint of kinds of machines, but broad types of implements are represented. For items not included some comparable machines appear in the list, and conclusions can be drawn with respect to the adaptability of wood for the use and the kind of wood that would be suitable.

No attempt has been made to list all the woods that might be used for the various implement parts. In some cases the use requirements are not exacting, and the list of satisfactory woods might be extended to include any species commonly available. The recommendations for woods take into consideration a number of factors, namely, strength properties, ability to stay in place, decay resistance, resistance to wear, availability, price, and others. The choice of a wood is based on a combination of these factors. Occasionally a certain wood is exceptionally adapted to meet an outstanding requirement, as, for instance, the ability of hickory to withstand the vibration and shock to which a pitman rod is subjected. Broadly, however, woods fall into property groups, and within these groups there is often considerable latitude for selection. There are the dense (or heavy) hardwoods, such as oaks, elms, hickories, ashes, maples, birches; the nondense (light-weight) hardwoods represented by such species as the cottonwoods, basswood, yellowpoplar; the dense softwoods, of which southern yellow pine, Douglas-fir, and western larch are are examples; the nondense softwoods, such as the soft pines, true firs, spruces, and cedars. Naturally there are no sharp lines separating one group

from another, but on the average the dense hardwoods are stronger than the nondense, the dense softwoods stronger than the nondense, and the dense softwoods are stronger than the nondense hardwoods. Thus, there are cases where a use requirement is such that the choice of wood may be from more than one group. Where strength is a requirement, the dense hardwoods or dense softwoods include the suitable woods; where the use is chiefly a matter of coverage the suitable wood will most likely be found among the nondense hardwoods or the nondense softwoods.

Strength properties alone do not govern the choice of woods. Woods with excellent mechanical properties may not be available in the sizes required, they may not be obtainable through regular lumber market channels, or they may be had only at prohibitive prices. Insofar as possible these various factors have been given weight in preparing table 2.

## Alternate Names for Species

U. S. Forest Service nomenclature has been used here in listing woods. In some cases this differs from the commonly accepted commercial or trade nomenclature. In order that there may be no misunderstanding the chief instances where differences occur are pointed out in the following tabulation:

| Nomenclature in Lists | Common Trade Name |
|---|---|
| Red pine | Norway pine |
| Water tupelo | Tupelo |
| Sweetgum | Red gum |
| Baldcypress | Cypress |
| Sugar maple | Hard maple, rock maple |

When oak is listed it is meant to include the commercial white oaks or commercial red oaks. White ash includes the ashes accepted in the white ash group. Hickory includes the true hickories as distinguished from the pecan hickories.

Southern yellow pine includes principally longleaf, shortleaf, loblolly, slash, and pond pines. The dense wood of any southern pine has practically the same strength and characteristics as the dense wood of any other southern pine, and the lighter pieces are more or less alike. Where high strength values are important, longleaf pine or dense southern yellow pine have been suggested. The term "dense", when used in connection with southern yellow pine and Douglas-fir, refers to lumber graded under a density specification.

Spruce includes any of the spruces, regardless of species, which may be available in lumber form to the fabricating plant.

Rock elm refers to the true rock elm only, and not to the elm of other species sometimes designated in the trade as rock elm.

Table 2.--Substitutions in specific implement parts and by kinds of wood

| Equipment and parts | Serviceable woods |
|---|---|
| Binders, combines (grain, rice, etc.) | |
| Decks | Oak, sugar maple, southern yellow pine, Douglas-fir |
| Reel | Southern yellow pine, red pine, Douglas-fir, ponderosa pine, yellowpoplar, basswood |
| Divider board | Southern yellow pine, oak, white ash, sugar maple, yellow birch, cottonwood, yellowpoplar, Douglas-fir |
| Pitman rod | Hickory, sugar maple, white ash, oak |
| Lever | Hickory, white ash, sugar maple, oak, yellow birch. |
| Rein guide | White ash, oak, sugar maple |
| Rollers | Sugar maple, yellow birch, southern yellow pine, oak |
| Conveyor slats | Yellow birch, beech, sugar maple, hickory, pecan, oak, white ash |
| Brooders (poultry, battery type) | |
| Framework | Oak, sugar maple, yellow birch, southern yellow pine, Douglas-fir, white ash |
| Corn shellers (hand and power) | |
| Hopper, bang board | Cottonwood, sweetgum, water tupelo, blackgum, southern yellow pine, Douglas-fir |
| Cob stacker | Southern yellow pine, Douglas-fir |
| Base | |
| Frame | Oak, sugar maple, beech, white ash, southern yellow pine, Douglas-fir |
| Panels | Cottonwood, yellowpoplar, basswood |
| Grain and feeder elevators | Southern yellow pine, Douglas-fir, ponderosa pine, white pine, spruce |
| Cultivators (tractor, sulky) | |
| Lever | Hickory, white ash, sugar maple, oak, yellow birch |
| Diggers (walking units) | |
| Handles, beams, and levers | Oak, white ash, hickory |

Table 2 (continued)

| Equipment and parts | Serviceable woods |
|---|---|
| Drills | |
| Hopper | Yellowpoplar, redwood, baldcypress, southern yellow pine, western hemlock, cottonwood, sweetgum |
| Footboard | Southern yellow pine, oak, white ash, sugar maple, Douglas-fir |
| Wheels (see wagons) | |
| Levers | Hickory, white ash, sugar maple, oak, yellow birch |
| Elevators (portable) | |
| Conveyor chute | Southern yellow pine, Douglas-fir, western larch, cottonwood, baldcypress, redwood |
| Conveyor cleats | Oak, southern yellow pine |
| Chute derrick | Oak, southern yellow pine, Douglas-fir, western larch |
| Wagon hoist derrick | Oak, southern yellow pine, Douglas-fir, western larch |
| Hopper | Southern yellow pine, Douglas-fir, western larch |
| Ensilage and hay cutters | |
| Feeder sides | Southern yellow pine, Douglas-fir, western larch, yellowpoplar, oak, white ash, cottonwood, basswood |
| Conveyor slats | Oak, sugar maple, beech, yellow birch, white ash, pecan |
| Feed grinders | |
| Hopper | Southern yellow pine, Douglas-fir, yellowpoplar, baldcypress, western larch |
| Stand | Oak, sugar maple, white ash, beech, yellow birch |
| Skids | Southern yellow pine, Douglas-fir, western larch, any dense hardwood |
| Feeders, hog | |
| Hopper | Southern yellow pine, western larch, Douglas-fir, western hemlock, white pine, red pine |
| Cover | Southern yellow pine, Douglas-fir |
| Trough | Oak |
| Skids | Southern yellow pine, Douglas-fir, western larch, any dense hardwood |
| Feeders, poultry | |
| Stand and trough | Southern yellow pine, Douglas-fir, redwood, baldcypress, cedar, cottonwood, ponderosa pine, basswood, sweetgum |

Table 2 (continued)

| Equipment and parts | Serviceable woods |
|---|---|
| Fertilizer distributors | |
| Hopper | Southern yellow pine, baldcypress, Douglas-fir, redwood, cottonwood, basswood, white pine, yellowpoplar |
| Hames | Sugar maple, yellow birch, beech, white ash |
| Hammer mills | |
| Feed tables | Southern yellow pine, Douglas-fir, any dense hardwood |
| Side and top-plates | Any commercial softwood |
| Skids | Southern yellow pine, Douglas-fir, any dense hardwood |
| Frame | Oak, white ash, sugar maple, yellow birch, beech |
| Harrows, drag | |
| Tooth bars | Oak, white ash, sugar maple |
| Draw bar | Oak, southern yellow pine, white ash, hickory, Douglas-fir |
| Lever | Hickory, white ash, sugar maple, oak, yellow birch |
| Harrows, disc | |
| Weight boxes | Oak, sugar maple, white ash |
| Bushings | Sugar maple, persimmon, dogwood |
| Levers | Hickory, white ash, sugar maple, oak, yellow birch |
| Harrows, spring tooth | |
| Draw bar | Oak, southern yellow pine, white ash, hickory, Douglas-fir |
| Lever | Hickory, white ash, sugar maple, oak, yellow birch |
| Hay loaders | |
| Conveyor cleats | Oak, sugar maple, yellow birch, white ash, hickory |
| Rake bars, deck, and deck sides | Southern yellow pine, Douglas-fir |
| Hay presses | |
| Feedtable | Southern yellow pine, Douglas-fir, red pine |
| Division blocks | Southern yellow pine, yellowpoplar, Douglas-fir, sweetgum, cottonwood, oak |
| Block setter head | Oak, sugar maple, white ash, hickory, any dense hardwood |
| Running gear | Oak, white ash, hickory |
| Frame | Sugar maple, any dense hardwood |

Table 2 (continued)

| Equipment and parts | Serviceable woods |
|---|---|
| Hay rakes, sulky | |
| Tooth bars | Oak, sugar maple, white ash, Douglas-fir, yellow birch, southern yellow pine |
| Wheels (see wagons) | |
| Hay rakes, sweep | Southern yellow pine, Douglas-fir, oak |
| Teeth | |
| Hitch parts | |
| Neck yoke, singletree, doubletree, evener, and draw bar | Oak, hickory, white ash, sugar maple, beech, yellow birch, rock elm, black locust, sweetgum, dense southern yellow pine, dense Douglas-fir |
| Hillers, walking | |
| Beam, handles, guide | Oak, white ash, hickory |
| Hog feeders, rotary | |
| Hopper | Southern yellow pine, Douglas-fir, baldcypress, redwood, western larch |
| Incubators | Western redcedar, redwood, baldcypress |
| Lime spreaders | |
| Hopper | Southern yellow pine, Douglas-fir, baldcypress, cottonwood, yellowpoplar, basswood, sweetgum |
| Wheels (see wagons) | |
| Manger partitions | Any commercial softwood, any commercial hardwood |
| Manure spreaders (see wagons) | |
| Mowers | |
| Divider or swath board | Southern yellow pine, Douglas-fir, cottonwood, yellowpoplar |
| Lever | Hickory, white ash, sugar maple, oak, yellow birch |
| Pitman rod | Hickory, sugar maple, white ash, oak |
| Divider board stick | Oak, white ash, sugar maple, yellow birch, southern yellow pine, Douglas-fir |
| Pickers and huskers | |
| Elevators | Southern yellow pine, Douglas-fir, yellowpoplar, cottonwood |
| Conveyor flights | Oak, birch, maple, beech |
| Gatherers | Oak, sugar maple, yellow birch, southern yellow pine, Douglas-fir, red pine |

Table 2 (continued)

| Equipment and parts | Serviceable woods |
|---|---|
| Pickers, peanut | |
| Frame | Southern yellow pine, Douglas-fir, oak, maple |
| Agitator bars | Oak, maple, hickory, white ash, beech, yellow birch, southern yellow pine, Douglas-fir |
| Fan housing | Yellowpoplar, cottonwood, basswood |
| Hopper | Oak, sugar maple, beech, yellow birch, white ash |
| Chute | Yellowpoplar, cottonwood, basswood, magnolia |
| Trucks (see wagons) | |
| Planters, corn, potato, etc. | |
| Hoppers | Southern yellow pine, Douglas-fir, cottonwood, yellowpoplar |
| Levers | Hickory, white ash, sugar maple, oak, yellow birch |
| Wheels (see wagons) | |
| Planters, garden | |
| Wheels (see wagons) | |
| Frame, guide handles | Oak, white ash |
| Hopper | Cottonwood, yellowpoplar, basswood, white pine, red pine, ponderosa pine, gum |
| Plows, cultivators, walking | |
| Beams, stretchers, and guide handles | Oak, white ash, hickory, sugar maple |
| Frame | Any dense hardwood |
| Wheel (see wagon) | |
| Plows, sulky and tractor | |
| Levers | Hickory, white ash, sugar maple, oak, yellow birch |
| Poles, implement | Longleaf pine, Douglas-fir (dense) |
| Potato sorter and grader | |
| Hopper | Southern yellow pine, Douglas-fir, oak |
| Rollers | |
| Platform, draw bar | Oak, white ash, hickory, southern yellow pine, Douglas-fir |

Table 2 (continued)

| Equipment and parts | Serviceable woods |
|---|---|
| Skids, engine and other | Oak, southern yellow pine, Douglas-fir, western larch, any dense hardwood |
| Sleighs | |
| Runners | Rock elm, oak, hickory, white ash |
| Sowers, hand | |
| Hopper | Cottonwood, yellowpoplar, basswood, pines, Douglas-fir, spruce |
| Spraying machines | |
| (See tanks) | |
| (See poles, implement) | |
| Stanchions | |
| Side bars | Sugar maple, yellow birch, beech, white ash, oak, hickory, pecan |
| Tanks, watering | |
| Storage, cooling | Baldcypress, Douglas-fir, redwood, cedar, white oak, southern yellow pine |
| Thills | White ash, oak, hickory, southern yellow pine |
| Tongues or poles | |
| (See wagons, tongues) | |
| Wagons, spreaders | |
| Floor boards | Edge-grained Douglas-fir, edge-grained southern yellow pine, edge-grained western larch, yellow birch, sweet birch, white ash, beech, oak, sugar maple |
| Sills | Southern yellow pine, Douglas-fir, oak, hickory, pecan, ash |
| Scoop boards | Edge-grained southern yellow pine, edge-grained Douglas-fir, edge-grained western larch, any dense hardwood |
| End ladders | Southern yellow pine, Douglas-fir, oak, white ash, hickory, yellow birch, beech, sugar maple |
| Side and end boards | Yellowpoplar, cottonwood, basswood, oak, white ash, southern yellow pine, Douglas-fir, baldcypress, yellow birch, sugar maple |
| Footboards | Same as for floor boards |
| Seat | Yellowpoplar, white pine, cottonwood, basswood |
| Cleats (see hounds, below) | |

Table 2 (continued)

| Equipment and parts | Serviceable woods |
|---|---|
| **Wagons, spreaders, trailers, trucks:** | |
| Hubs | Rock elm, oak, black locust, sugar maple, sweet birch, yellow birch |
| Felloes and rims | Hickory, oak, white ash, rock elm, yellow birch, sugar maple |
| Spokes | Hickory, oak, rock elm, white ash, yellow birch, sweet birch, sugar maple |
| Tongue and reach | Oak, white ash, southern yellow pine, Douglas-fir |
| Axles | Hickory, white ash, sugar maple, oak, pecan, yellow birch |
| Bolsters | Hickory, oak, white ash, sugar maple, pecan, yellow birch |
| Bolster stakes | Same as for hounds |
| Sand bolster | Hickory, oak, pecan, sugar maple, white ash, yellow birch |
| Hounds, and slider bar | Hickory, oak, white ash, rock elm, yellow birch, sugar maple, beech |
| Brake bar | Same as for axles |
| Brake block | Same as for axles |
| Brake bar hanger | Hickory, white ash, sugar maple, oak, pecan, yellow birch |
| **Waterers, poultry** | |
| Stands | Southern yellow pine, Douglas-fir, red pine, baldcypress, redwood |
| Troughs | Redwood, baldcypress, cedar |
| **Wheelbarrows** | |
| Handles | Oak, hickory, sugar maple, yellow birch, white ash, elm |
| Trays, garden type | Basswood, yellowpoplar, cottonwood, sweetgum, water tupelo |
| Trays, utility type | Elm, oak, sugar maple, beech |
| **Windmills** | |
| Platform | Baldcypress, redwood, white oak, Douglas-fir, southern yellow pine, western larch, cedar |
| Sails | Baldcypress, yellowpoplar, spruce, basswood |
| Arms | Oak, southern yellow pine, Douglas fir |
| Tower | Southern yellow pine, Douglas-fir, western larch, oak, sugar maple, yellow birch, white ash |
| Pump pole | White ash, hickory, oak, southern yellow pine, Douglas-fir |
| Ladder | Southern yellow pine, oak, sugar maple, yellow birch, Douglas-fir, white ash |
| Sucker rods | White ash, hickory, southern yellow pine, Douglas-fir |
| Pump jack | Southern yellow pine, Douglas fir |

## Availability of Species

During the war period it is impossible to state with certainty the extent to which the individual species are available for farm implement and equipment manufacture. As demand for wood increases with expanding military uses and substitution becomes necessary because of limitation of use of critical materials the supply situation is constantly changing. A wood that is available in abundance today may be less available tomorrow. The recent order freezing certain grades of softwood construction lumber is a case in point. However, the shop and factory grades are not frozen so that the supply although narrowed in range may still be sufficient in quantity and quality to meet any demands that might come from farm implement manufacturers and other users of lumber in remanufactured form.

Certain hardwoods have been relatively scarce for some time because of abnormal demand for special war uses. White oak, white ash, and yellow birch are examples. There are other woods that will give comparable service.

Some woods are abundant in certain localities, and yet not generally available throughout the territory in which the farm implement industry is largely concentrated. For instance, black locust is abundant in the Appalachian region from Pennsylvania south into Georgia and Alabama and in parts of the Ohio Valley, yet it comes into the general lumber markets only in small quantities because it is not a general purpose wood.

Certain woods with excellent properties are available in the sizes required only at prohibitive prices. Among such are dogwood, persimmon, and osageorange. Unless a manufacturer is unusually well located with respect to supply of these woods they should be considered in the unavailable class.

## Optional Forms of Wood Stock and Sources of Supply

A wood user has much the same option in buying stock as has the metal user. He may buy material in unworked form or he may buy parts for his product in machined form ready to assemble at his factory. There are many substantial sawmills and woodworking plants that are equipped with dry kilns and machinery that are capable of doing just as good a job as the factories themselves. For farm equipment plants without woodworking machinery or men familiar with woodworking the purchase of ready-cut parts offers a solution to the problem of changing from metal to wood. For factories equipped with facilities for working wood the opportunity to buy parts cut and dried to their requirements has some distinct advantages. It enables them to increase production at a rapid rate without overloading their wood preparatory shops. Another decided advantage is elimination of a large lumber inventory with the many items of direct and indirect costs that go with it. The advantage of a substantial back-log of lumber is that the factory is more or less independent of extreme fluctuations in prices and there is also less danger of a breakdown in supply flowing to the assembly shop. At the present time ceiling prices on most lumber items have eliminated the danger of run-away prices, so that the argument for a large lumber inventory loses much of its force.

On the basis of a thousand board feet, cuttings bought ready-cut and cuttings obtained by a factory from lumber in its own shop should not vary greatly in cost. The advantage is usually on the side of ready-cut stock as a factory operator who has included all of his costs knows. It is the advantages aside from apparent costs that often strengthen the case for ready-cut stock.

A convenient method of locating sources of supply for lumber and ready-cut stock is through lumber trade associations. Among the lumber associations important from the standpoint of farm equipment manufacturers are the

National Hardwood Lumber Association
59 East Van Buren St., Chicago, Illinois

Northern Hemlock & Hardwood Manufacturers' Association
Oshkosh, Wisconsin

Southern Hardwood Producers,
805 Sterick Building, Memphis, Tenn.

Northeastern Lumber Manufacturers' Association
271 Madison Avenue, New York, N. Y.

Southern Pine Association
Interstate Bank Building, New Orleans, La.

West Coast Lumbermen's Association
364 Stuart Building, Seattle, Wash.

Western Pine Association
510 Yeon Building, Portland, Oregon

Appalachian Hardwood Manufacturers, Inc.
414 Walnut Street, Cincinnati, Ohio

Hardwood Dimension Manufacturers' Association
229 Heyburn Building, Louisville, Ky.

A request to the National Lumber Manufacturers' Association, 1337 Connecticut Avenue, N. W., Washington, D. C., will always bring pertinent information whether the inquiry concerns hardwoods or softwoods.

## Plywood

Were circumstances normal resin-bonded plywoods would be available for many uses. They are especially useful where coverage is the chief requirement. Such plywoods are so extremely resistant to moisture that they will withstand prolonged exposure to weather. However, present military demands for this type of plywood plus the demand for the materials from which the synthetic resin glues are made create a situation which leaves limited quantities for ordinary civil uses.

Where equipment is used indoors or is exposed to the weather for only short periods plywoods formed with other glues will give good service. For some uses plywood has qualities superior to those of solid wood. It swells and shrinks less than solid wood when exposed to changes in humidity. It is effectively resistant to checking. It can be obtained in wide, long panels, and where rigidity is a factor large, unbroken sections have a decided advantage over sections of the same size composed of a number of narrow pieces not edge-glued.

Plywoods are available in various thicknesses and of different woods. Among the sources for information on plywood supplies and uses are the Hardwood Plywood Institute, 205 West Wacker Drive, Chicago, Illinois, and the Douglas Fir Plywood Association, 1203 East D Street, Tacoma, Washington. Most local lumber distributing agencies can be relied on for information on plywood that will be helpful to prospective users.

## Fibre Boards and Wall Boards

Of fibre boards there are several that might be considered as alternates to plywood. Some of these are hard and stiff, and serve well for coverage. Properly coated they will stand severe exposure to the weather. They may be obtained in large panels, 4 feet by 8 feet, and in thicknesses from 1/8 inch up.

Another type of wall board is that made from minerals or minerals combined with wood or other fibres. Examples of these are gypsum boards and asbestos-cement boards. These are highly fire-resistant, and are especially adaptable to uses where the fire hazard is a factor to be reckoned with.

Information on fibre boards or wall boards is generally available from local building material supply agencies.

## Classification of Woods According to Important Properties

Table 4 shows in approximate terms the property relationships of a number of the commercially important woods. Provided a prospective user knows the requirements for a specific purpose the table may be used as a guide in the choice of woods for items not included in table 2. Usually the choice is determined by a combination of two or more properties along with the factor of price and availability. Where requirements are not exacting price may be more important than properties of the woods, and again where two or more woods have almost identical property ratings, advantage as represented by price may outweigh other considerations.

For the more complete information on wood properties that every designing engineer should have there is available from the Superintendent of Documents, Washington, D. C., the "Wood Handbook," price 35 cents (cash or money order, stamps not accepted). It deals in detail with wood as a material of construction, and contains data for its use in design and specifications.

## Use of Wood in New Forms and by New Methods

New forms of wood products, new processes, new treatments, new equipment, and new fastenings have come into existence since wood began to recede from use in agricultural implements. With the exception, however, of the structural use of plywood and dense fiber boards and improved kiln-drying facilities the prospective user or designing engineer should not put too much reliance on using wood in some radically new form. This is not to minimize the importance of the new developments, but to focus on the obvious fact that the important substitutions of wood for other materials in the implement field for the immediate present will be through the use of conventional materials and forms. The fact that often critical materials are involved in the newer developments or that supply facilities cannot be set up at this time is the main reason why the designer must adhere largely to standard form. There are opportunities for the designer to show ingenuity and to devise short cuts using standard readily available forms of material without relying on forms more difficult to obtain.

In addition to the exceptions referred to above there are, however, certain rapidly growing practices that may be expected to find application in this field more readily than others. Reference is made to: (1) Special metal connectors to supplement bolted joints in heavy structural members. Such connectors are available on a license basis from one supply organization. (2) The lamination of curved or straight members, with moisture-resisting, cold-setting adhesives, by nail, clamp, or machine pressure. Glued, laminated products are available from a few producing plants which specialize in this business, or they can be made fairly readily by the user. Two uses in which laminated construction is known to have been used in the agricultural equipment field are for tongues and quite recently for heavy hoops for storage bins and silos.

Mysterious formulae for impregnations or coatings to eliminate the swelling and shrinking of wood have been commonly promoted, but wood still swells and shrinks. Soundly compounded, heavy-bodied coatings are effective in reducing the rate of dimensional change but not the amount of change. Considerable progress has been made in the development of coatings that reduce end splitting of lumber and logs incident to storage or seasoning. Fairly good fire-retardant paints are available for special usages if required. Information in this field can be supplied upon request.

Wood plastics, plasticized wood, compressed wood, and similar new products have special utilities and promise, but for quantity nondefense usage at present are practically out of consideration because of the difficulty of obtaining accessory materials or equipment needed in their production. As a substitute for brass in small bearings or similar parts certain products in the laminated plastic field do come in for consideration if the need is sufficiently important.

Table 4.--Broad classification of woods according to characteristics and properties

(A, among the woods relatively high in the particular respect listed;
B, among the woods intermediate in the particular respect listed;
C, among the woods relatively low in the particular respect listed)

| Kind of wood | Working and behavior characteristics | | | | | | | | | | Strength properties | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hardness | Weight, dry | Freedom from shrinkage | Freedom from warping | Ease of working | Paint holding | Nail holding | Decay resistance of heartwood | Proportion of heartwood[1] | | Bending strength | Stiffness | Strength as a post | Toughness |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | 11 | 12 | 13 | 14 |
| Ash, white | A | A | B | B | C | | A | C | C | | A | A | A | A |
| Ash, black | A | B | C | B | C | | | C | C | | B | B | C | A |
| Baldcypress | B | B | B | B | B | A | B | A | B | | B | B | B | B |
| Basswood | C | C | C | B | A | | C | C | C | | C | B | C | C |
| Beech | A | A | C | C | C | | A | C | B | | A | A | B | A |
| Birch, yellow | A | A | C | B | C | | A | C | C | | A | A | B | A |
| Cedar, northern white | C | C | A | A | A | A | C | A | A | | C | C | C | C |
| Cedar, western red | C | C | A | A | A | A | C | A | A | | C | C | B | C |
| Chestnut | B | B | B | A | B | | B | A | A | | C | C | C | B |
| Cottonwood | C | B | C | C | B | | C | C | C | | C | B | C | B |
| Douglas-fir | B | B | B | B | C | C | B | B | A | | A | A | A | B |
| Elm, soft | A | A | C | C | C | | A | B | B | | B | B | B | A |
| Elm, rock | A | A | C | B | C | | | B | B | | A | A | B | A |
| Fir, balsam | C | C | B | B | B | B | | C | B | | C | C | C | C |
| Fir, white | C | C | B | B | B | B | C | C | C | | B | B | B | C |
| Hackberry | A | A | C | B | C | | | | C | | B | C | C | A |
| Hemlock, eastern | B | B | B | B | B | B | B | C | B | | B | B | B | B |
| Hemlock, western | B | B | B | B | B | B | B | C | C | | B | A | B | B |
| Hickory, true | A | A | C | B | C | | A | C | B | | A | A | A | A |
| Hickory, pecan | A | A | C | B | C | | | C | B | | A | A | A | A |
| Larch, western | A | A | B | B | C | C | A | B | A | | A | A | A | B |
| Locust, black | A | A | B | B | C | | A | A | A | | A | A | A | A |
| Maple, hard | A | A | C | B | C | | A | C | C | | A | A | A | A |
| Maple, soft | A | A | B | B | C | | A | C | C | | C | C | C | C |
| Oak, red | A | A | C | B | C | | A | C | B | | A | A | B | A |
| Oak, white | A | A | C | B | C | | A | A | B | | A | A | B | A |
| Pine, ponderosa | C | B | B | A | A | B | B | (2) | C | | C | C | C | C |
| Pine, southern yellow | A | A | B | B | C | C | A | B | C | | A | A | A | B |
| White pine group: | | | | | | | | | | | | | | |
| Northern white | C | C | A | A | A | A | B | (2) | B | | C | C | C | C |
| Western white | C | B | B | A | A | A | B | (2) | B | | B | B | B | B |
| Sugar pine | C | C | A | A | A | A | | (2) | B | | C | C | C | C |



(continued)

Table 4 (continued)

| Kind of wood | Working and behavior characteristics | | | | | | | | | | Strength properties | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hardness | Weight, dry | Freedom from shrinkage | Freedom from warping | Ease of working | Paint holding | Nail holding | Decay resistance of heartwood | Proportion of heartwood[1] | | Bending strength | Stiffness | Strength as a post | Toughness |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | 11 | 12 | 13 | 14 |
| Redwood | B | B | A | A | B | A | B | A | A | | B | B | A | B |
| Spruce, eastern | C | B | B | A | B | B | B | C | C | | B | B | B | B |
| Spruce, Sitka | C | B | B | A | B | B | ... | C | C | | B | A | B | B |
| Spruce, Engelmann | C | C | B | A | B | B | C | C | C | | C | C | C | C |
| Sweetgum | B | B | C | C | B | ... | B | B | B | | B | B | B | B |
| Sycamore | A | A | C | C | C | ... | A | C | B | | B | B | B | B |
| Yellowpoplar | C | B | B | A | A | ... | B | C | B | | B | B | C | C |
| Water tupelo | A | A | B | C | C | ... | A | C | C | | B | B | B | B |

[1] Exclusive of the all-heartwood grades that are available on special order in birch, cedar, baldcypress, Douglas-fir, sweetgum, southern yellow pine, and redwood.

[2] Conflicting opinion and absence of adequate test data preclude a definite rating. Placing reliance on high decay resistance is not recommended when this wood is used untreated.

(concluded)

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## Softwoods

Softwood lumber is graded under rules issued by the various regional lumber inspection bureaus or associations. The following table indicates where to go for information on grading the various species referred to in table 2.

### Lumber Inspection Agencies

| Kinds of wood | Agency or association sponsoring grading rules | Address of association |
|---|---|---|
| Southern yellow pine | Southern Pine Inspection Bureau | Canal Building, New Orleans, La. |
| Baldcypress | Southern Cypress Manufacturers' Assn. | 722 Barnett National Bank Building, Jacksonville, Fla. |
| Douglas-fir, western hemlock, western redcedar, Sitka spruce | Pacific Lumber Inspection Bureau | 364 Stuart Building, Seattle, Washington |
| Eastern white pine, red pine, eastern spruce | Northern Pine Manufacturers' Assn. | 4438 Wentworth Avenue, Minneapolis, Minn. |
| Eastern spruce, northern white pine, red pine | Northeastern Lumber Manufacturers' Assn. | 271 Madison Avenue, New York, N. Y. |
| Redwood | California Redwood Assn. | 405 Montgomery Street, San Francisco, Calif. |
| Ponderosa pine, western white pine, western larch, sugar pine, western redcedar | Western Pine Association | 510 Yeon Building, Portland, Oregon |
| Eastern hemlock | Northern Hemlock and Hardwood Manufacturers' Association | P. O. Box 1040, Oshkosh, Wis. |

## Hardwoods

Standard grading rules for grading all commercially important hardwoods are issued by the National Hardwood Lumber Association, 59 East Van Buren Street, Chicago, Illinois. Among the woods included are oak, maple,

ash, elm, basswood, beech, birch, hickory, sweetgum, yellowpoplar, cottonwood, pecan, locust, tupelo. Also included in the rules issued by this association is cypress.

## Lumber Prices

Information on current lumber prices is published in various trade journals. Among such are the following: American Lumberman, Commercial Bulletin, New York Lumber Trade Journal, Southern Lumberman, and West Coast Lumberman. Published price information is chiefly valuable for comparison of species. Prices are quoted with reference to specific markets so that they are not reliable indexes of what the costs might be delivered to certain points distant from the price basing centers.

There are no published prices for dimension or ready-cut stock.

## Seasoning

Wood used in the manufacture of farm machinery and equipment will not give its best service unless it has been properly dried before it is installed. Tests made by the Forest Products Laboratory show that wood for outdoor use should be dried to moisture contents of 7 to 14 percent based on oven-dry weight. For use in the dry southwestern states the average should be 9 percent and the variation in moisture content not greater than 7 to 12 percent. In the remainder of the United States the moisture content should be about 12 percent and variation not more than between 9 and 14 percent. Wood dried to these moisture contents will give satisfactory service in most items of farm machinery and equipment. It is especially recommended, however, that wood wheel and wagon box parts be thoroughly dried so there will be no further shrinkage after assembly.

### Moisture Content Tests

The moisture content of wood can be determined by any one of several methods, the most common of which are oven-drying tests and instantaneous electrical moisture meters. The oven-drying method is the more accurate but is slow, while the electrical method gives quick results, but is not accurate under all conditions.

In the oven-drying method, samples 3/4 to 1 inch long in the direction of the grain are sawed from representative boards or pieces. These samples should be cut at least 1 foot from the end of the piece to avoid the effects of drying from the ends, and should be free from knots and other defects.

Cutting samples for oven-drying tests.--Each sample is weighed immediately after cutting, placed in an oven heated to 212° to 221° F., and dried for 8 to 24 hours or until no more weight is lost. Scales or

balances with a capacity of about 200 grams and sensitive to 0.1 gram should be used. The following example illustrates how moisture content is computed:

$$\frac{\text{(Original weight) 125 grams} \quad \text{minus} \quad \text{(Oven-dry weight) 105 grams}}{\text{105 grams (Oven-dry weight)}} = \frac{20}{105} = 0.19 \text{ or } 19 \text{ percent}$$

Several types of portable electrical moisture meters are available with which the moisture content of wood can be determined directly. In using these instruments sharp, short, metallic terminals are imbedded in the wood, and the electrical resistance read from the instrument in terms of moisture content. The range of most of these instruments is about 7 to 24 percent. Electrical moisture meters measure the moisture content of the wettest wood with which the terminals come into contact. They are usually designed for use on lumber or wood parts which are about 1 inch thick and may not be accurate for thicker material -- which is normally wetter in the interior than on the surface. In wood thicker than 1 inch the moisture gradient may be estimated by using electrodes driven to different depths. These instruments will also be inaccurate in testing pieces which have for any reason been recently wet on the surface.

## Air Seasoning

Thoroughly air-dried wood will reach a moisture content of 12 to 15 percent, and is, therefore, usually at or above the maximum which should be used for farm equipment parts. For this reason it is important that manufacturers who have no kiln-drying facilities air dry their lumber to the lowest practicable moisture condition.

The methods of piling lumber for air seasoning have been studied in considerable detail, and considerable information is available covering the methods and practices which should be followed in order to get the best results. Following is a summary of these practices as concern the most important damages to lumber during air seasoning.

Lumber Piling Practices Which Will Reduce Seasoning Damage

| To reduce the occurrence of: | | | |
|---|---|---|---|
| Checking | Warping | Blue stain and decay | |
| Lower the foundations. Decrease the spacing between boards and between piles. Use thinner, narrower stickers. Place the end stickers so that they project beyond the ends of the pile. Use end coatings. | Use stickers of uniform thickness properly aligned and supported, and sufficient in number | Raise the foundations. Increase the spacing between boards and between piles. Provide one central flared chimney, or a series of narrow chimneys. Use thicker, narrower stickers. Build narrower piles. | Stain or decay occurring throughout the pile. |
| | | Provide short chimneys (1/3 or 1/2 height of pile). Use thicker stickers in the lower part of the pile. | Stain or decay occurring in the lower part of the pile only. |

## Kiln Drying

Advances in dry kiln construction, installation, and operation have been rapid, especially during the past 15 or 20 years. Most of the old-model kilns do not have the volume or quality of production which is possible in the newer units, in which temperature and relative humidity can be controlled more closely and in which the rate of circulation has been increased greatly.

As in the case of air seasoning, detailed studies and research have been conducted covering many important phases of dry kiln construction, operation, and maintenance. The following is a summary of these practices as they apply to some of the most important items of damage to wood during kiln drying:

Practices Which Will Reduce Kiln Drying Damage

To reduce the occurrence of:

| Surface checking | End checking | Warping | Honeycomb |
|---|---|---|---|
| Increase the rate of circulation. Use higher humidities at the beginning of run. | Pile more carefully. Use end coatings. | Pile more carefully, using more stickers. Increase rate of circulation through pile. Relieve casehardening. Use heavy weights on top of pile. | Prevent surface checking and minimize casehardening by using milder drying conditions. Get uniform circulation throughout pile. |

## End Coatings

Since wood dries faster from the end grain than from the side grain some kinds of wood, especially in thick sizes, may check and split during air seasoning. For this reason it is often advisable to use a moisture-resistant end coating for air seasoning or kiln drying.

Coatings ordinarily used are of two classes. Those in the first class are liquid at ordinary air temperatures and can be applied cold. Those in the second class are solid at ordinary temperatures, and must be heated before being applied. The hot or cold coatings are effective for drying temperatures up to 140° F., but for temperatures between 140° and 170° hot coatings should be used.

The two best cold coatings developed are hardened gloss oil thickened with barytes and magnesium silicate (very cheap) and high-grade spar varnish and barytes (expensive).

The gloss oil is made up as follows: The oil should be of a thick grade made up (by the paint manufacturer) of about 8 parts by weight of quick lime, 100 parts rosin, and 57.5 parts mineral spirit. To 100 parts

of the gloss oil add 25 parts barytes and 25 parts of magnesium silicate. One or two parts of lampblack can be added if a black coating is desired. This coating can be made by any paint manufacturer, or it can be mixed by the user as needed, in case the proper grade of gloss oil is obtained. Some gloss oils have little moisture resistance, and it is necessary, therefore, that the coating be made up according to the above formula.

Paraffin is a satisfactory end coating for use on material which is to be air seasoned, but its melting point is too low for use on stock to be kiln dried.

The most effective method of applying hot coatings is to dip the ends of the stock about 1/2 inch into the coatings. For this reason it is difficult to apply these coatings to large-size material. Hot coatings are effective in the following order:

213° coal-tar pitch.....(cheap)
254° coal-tar pitch.....(cheap)
Rosin and lampblack (100 parts of rosin to 7 parts of lampblack).....(moderate cost)

## Preservative Treatment

The use of wood in farm machinery and equipment involves only relatively few parts and items in which preservative treatment or the use of naturally durable woods is necessary. These parts are, for example:

Skids -- for engines, shellers, self-feeders, hog traps, and other wood-mounted items

Tanks and silos -- for water and fodder storage

Foundations and frames -- the lower parts of which normally are in contact with the ground

The need for decay resistance in a wood part will be determined by use conditions. Resistance to rot is necessary in parts which are to be in direct contact with the ground and in parts which otherwise are used under conditions which result in the accumulation of moisture. For use under these conditions it is recommended that the wood parts concerned be treated by one of the following methods:

1. Pressure treatments -- using preservatives such as coal-tar creosote or pentachlorophenol solutions (for parts which are not to be painted), or zinc chloride (for parts which are to be painted). Pressure treatment is the most effective, and most expensive, treating method, and need be used only under conditions of high decay hazard.

2. Hot and cold bath treatments - are less expensive than the pressure treatments, and can be accomplished at the manufacturing plant. These are the most effective of the nonpressure treatments, and are suitable for decay protection under all but the most severe service conditions.

3. Steeping treatments - are generally less effective than the hot and cold bath methods. Mercuric chloride has been commonly used, but zinc chloride, sodium fluoride, and other water-soluble preservatives can be employed. Soaking dry wood in untreated solutions of pentachlorphenol gives some protection with practically any wood and may give excellent results with woods that are easy to treat.

4. Dipping treatments - using hot preservatives, such as the creosotes or pentachlorphenol solutions, have only limited effectiveness under severe service conditions.

5. Brushing and spraying treatments - that are sometimes used with preservative oils, are the least effective methods of protecting wood from decay.

Detailed information on these treatments and the chemicals used is available from the Forest Products Laboratory.

## Bent Wood Equipment Parts

Curved members of wood are produced by band sawing or by bending. Band-sawed parts are more subject to splitting and breaking because the direction of the grain of the wood does not follow the curvature of the piece. Thin stock bends more readily than thick stock; therefore, bent single pieces are sometimes glued together to produce a part of the required thickness.

In making single-piece bent members the stock must be softened, and heated usually with steam or hot water, to permit the required deformation. Straight-grained material free from defects is essential for bends that involve extreme deformations.

Hardwoods, especially elms, ashes, hickories, withstand extreme bending better than softwoods -- pines, firs, hemlocks, etc. The oaks, beech, birches, maples, and gums can be successfully bent.

Wood that has been steam-bent should preferably be dried on forms or otherwise held to desired shape until at about the moisture content it will have in service is reached.

An extremely important factor in bending wood successfully is the design of the mechanical apparatus used for applying pressure. Many commercial losses in bending can be prevented through the use of proper equipment. The use of adequate straps on the tension side of the bend and proper pressure take-up devises for the ends of the pieces are features commonly overlooked. This is a clear-cut mechanical problem, not one that has to be left to chance and the so-called vagaries of wood.

Wood loses some of its strength in bending, the amount of loss depending upon the severity of the bend. Trade directories include the names of concerns that specialize in wood bending. In some cases it may be advantageous to investigate the capacities of such plants for undertaking special bending jobs.

## Wood-damaging Insects

Implement stock in dry storage is sometimes badly damaged by the larvae of the powder-post beetle, so it is well to be on the lookout for this destructive insect. Evidence of its work is the accumulation of a fine powder coming from holes 1/16 to 1/12 inch in diameter. When these holes are numerous they weaken the wood to a considerable degree.

Woods preferred by these insects are ash, hickory, and oak; other hardwoods, including maple, elm, and poplar, are affected to a lesser extent. Only seasoned sapwood of these woods is damaged; therefore, wood that has been in dry storage for a considerable period of time needs close watching and preferably old stock should be used before newly-piled material.

Since the eggs of the insect are laid in the open pores of the wood any finish, such as paint, varnish, or boiled linseed oil, will effectively prevent infection. If infestation is already present, sterilization may be accomplished by steaming at not less than 130° F., treatment in a dry kiln at 180° for 1-1/2 hours is effective for inch lumber, and a proportionately longer time for thicker lumber.

Where practical the infestation may be halted by a thorough application of kerosene or a mixture of three parts kerosene and one part coal-tar creosote.

The following points are set down to sum up this discussion:

1. Commonly affected woods are ash, oak, hickory.
2. Heartwood is not affected.
3. Only seasoned sapwood is affected.
4. Keep old stock moving.
5. If practical, paint or finish parts to be stored.
6. If practical, sterilize wood with steam or dry kiln treatment.
7. Where practical, halt infestation with kerosene or kerosene-coal-tar creosote mixture.

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